



Internationally Interoperable Data Systems Critical Enabler for Collaborative International Exploration

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IOP / IOAG History



IOP-1 Held in 1999

- To foster strategic space operations planning and interoperability
- Chartered the IOAG
 - Translates IOP guidance into interoperable architectures

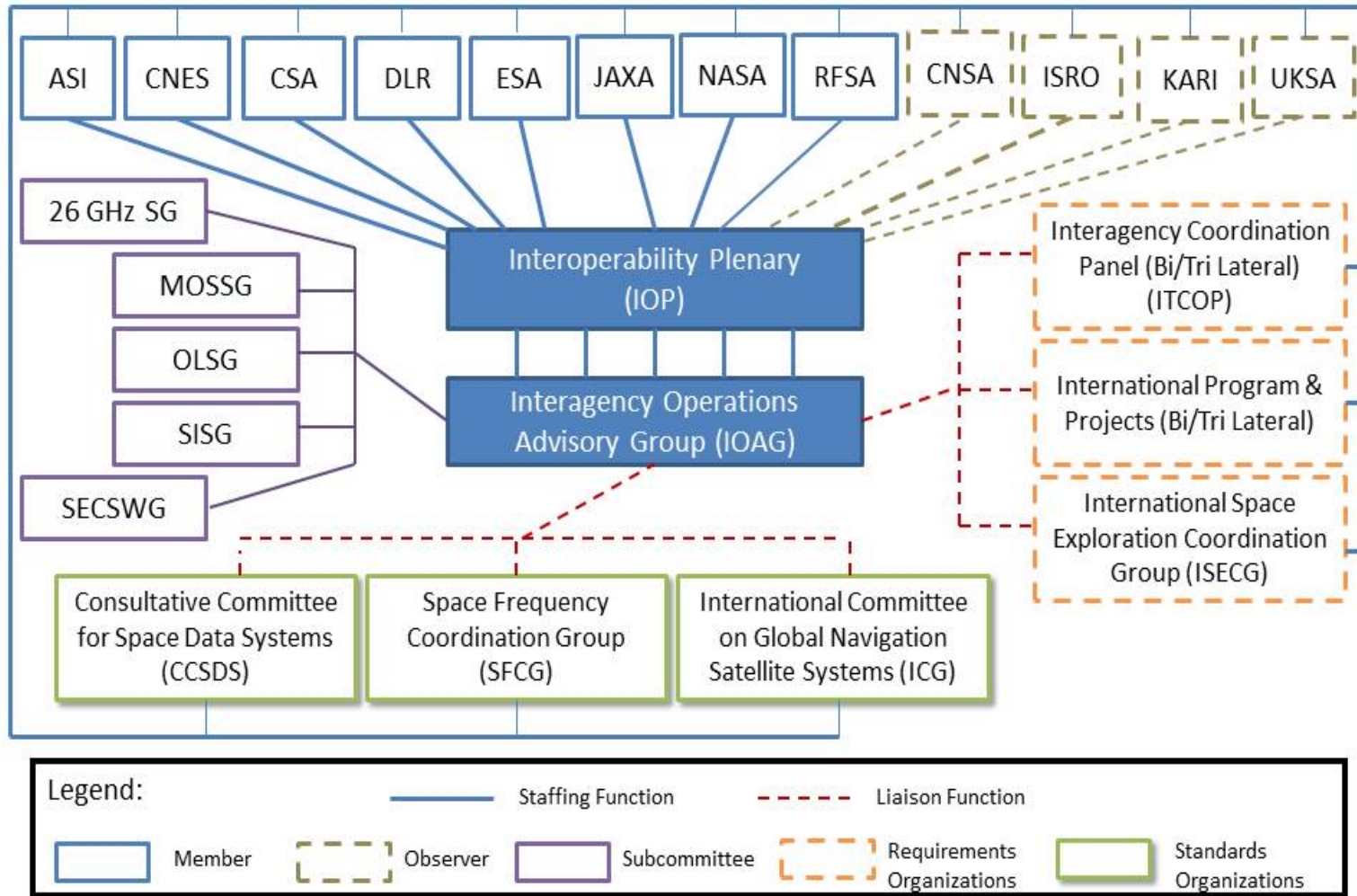
IOP-3 held in 2013 / CNES

- For a history of the IOP/IOAG's first decade
 - *"The Interagency Operations Advisory Group (IOAG)- A decade of leadership in International Space Cooperation."*
- For information on IOP-3 see the IOP website or
 - *"Results from the recent Interoperability Plenary-3, and the implication on future interoperability for global space communication and operations architectures"*



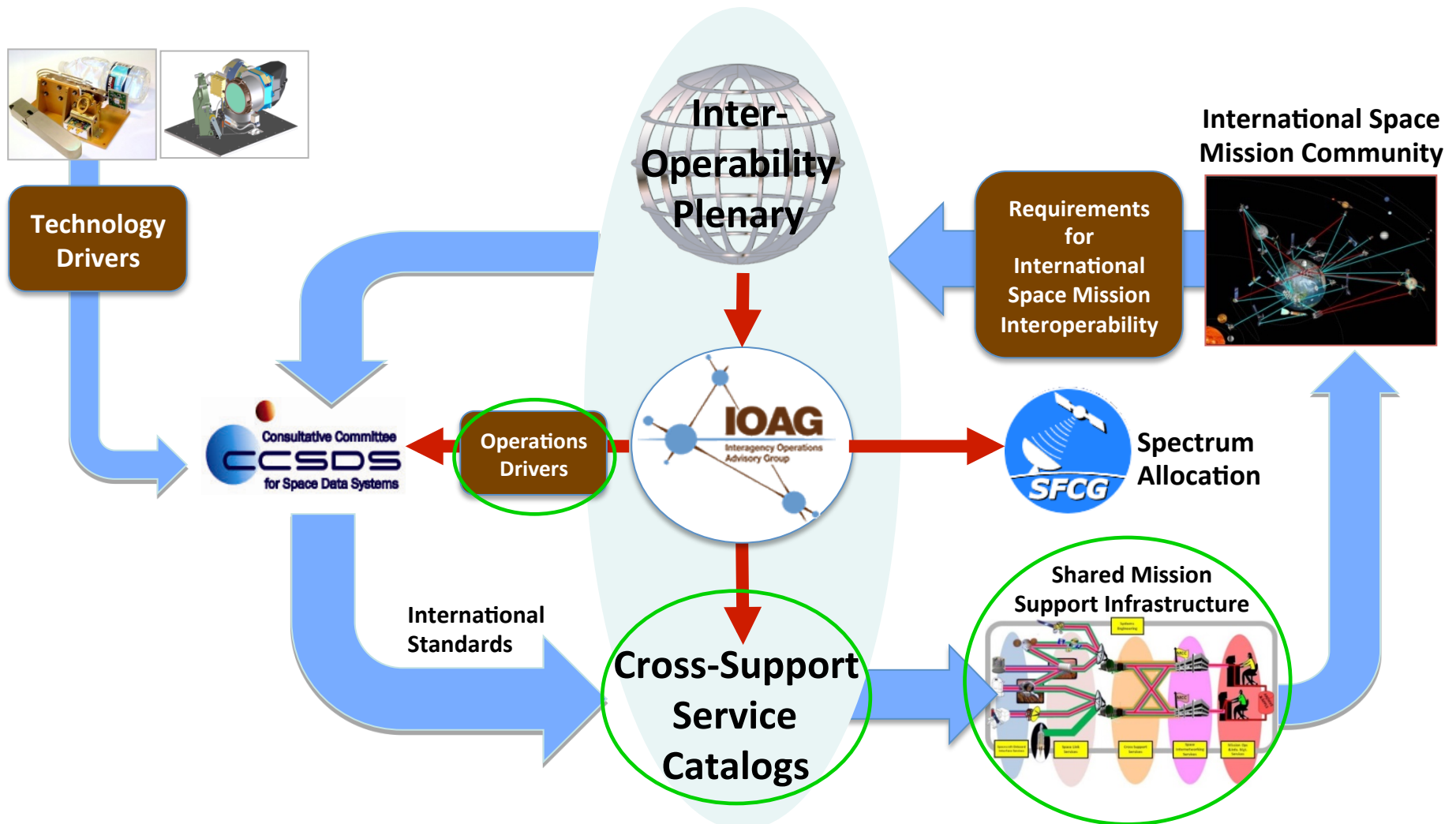


IOP / IOAG Organization





Central Role of IOP / IOAG





IOP-3 Results



The IOAG received a strong endorsement of all of it's Recommendations and Liaisons Including:

1. Defining a path forward for global interoperability in:

- Space Internetworking
- Optical Communications Links
- Mission Operations Systems
- Low Earth Orbit 26GHz

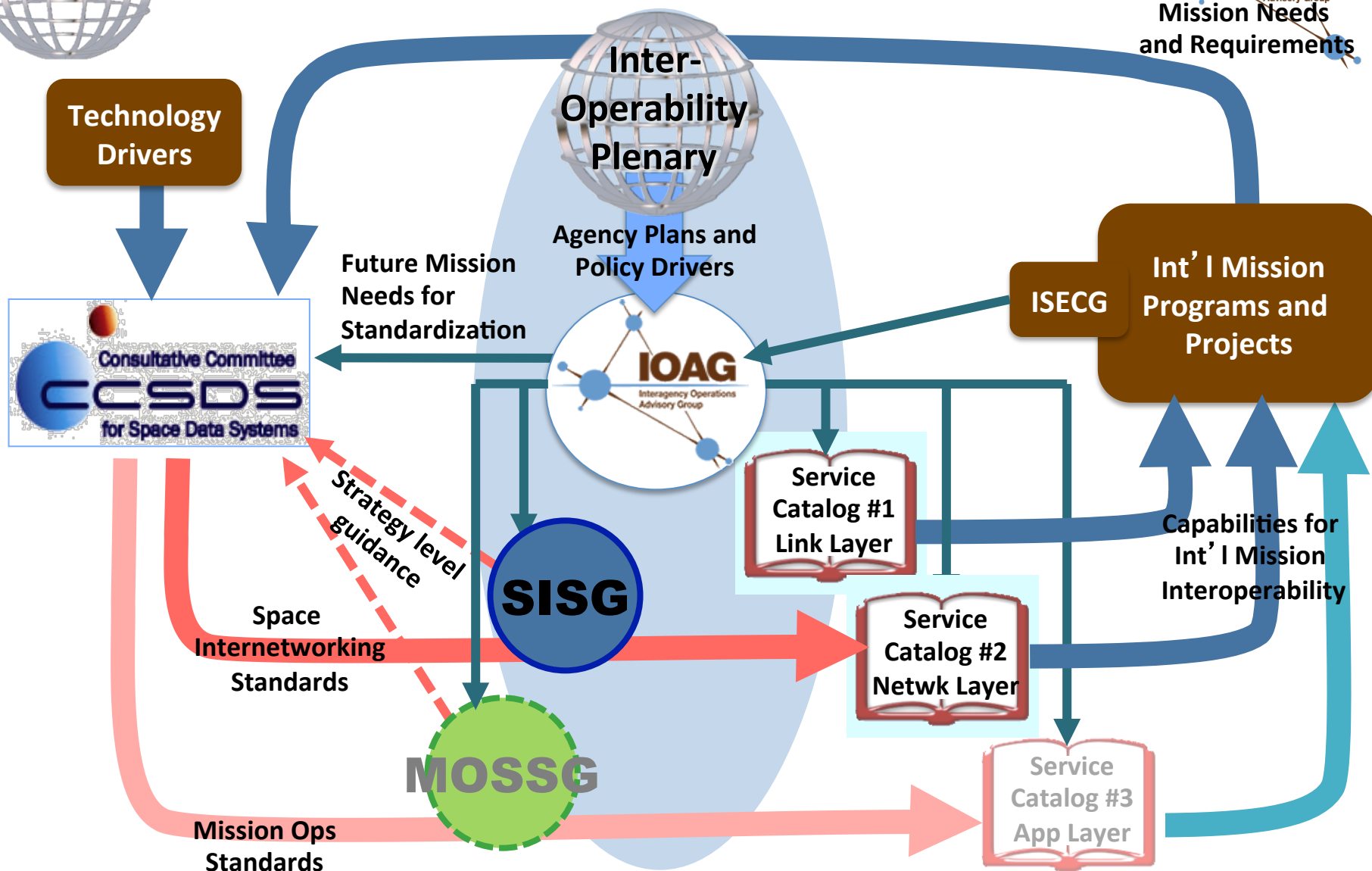
2. Mandate for Effective Liaisons with

- CCSDS
- SFCG
- ICG
- ISECG



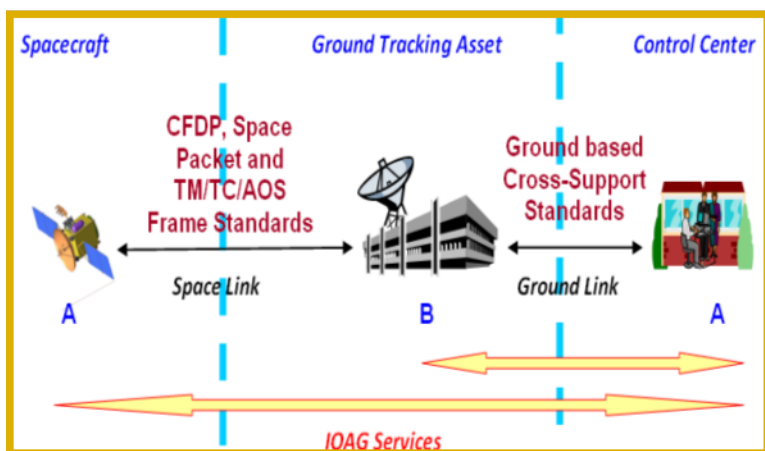
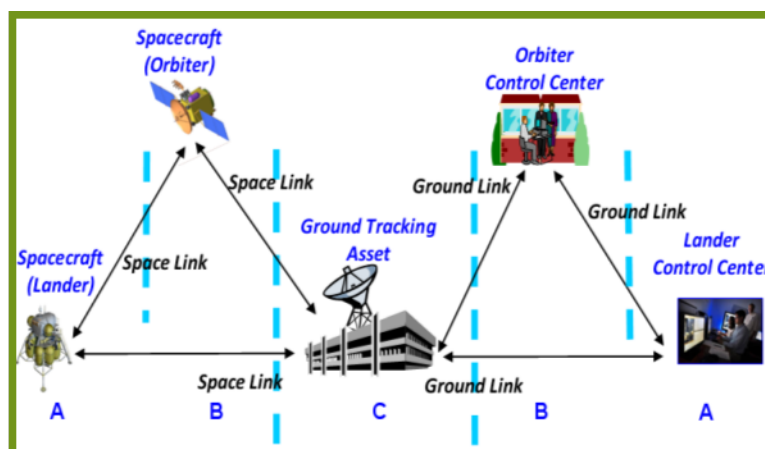


IOAG Service Catalogs Post IOP-3



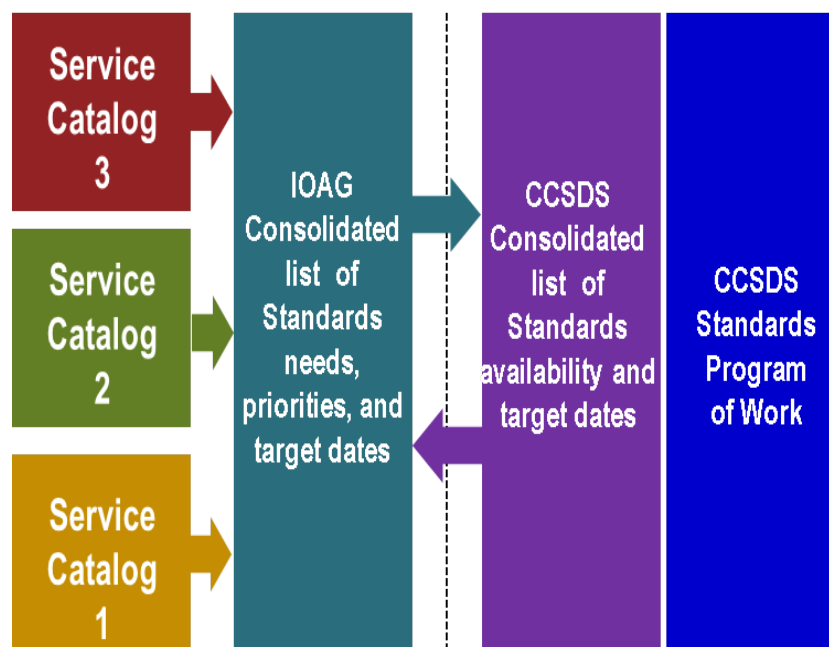


IOAG CCSDS Product Agreement (ICPA)



IOAG

CCSDS



ICPA



CCSDS Overview - Participation

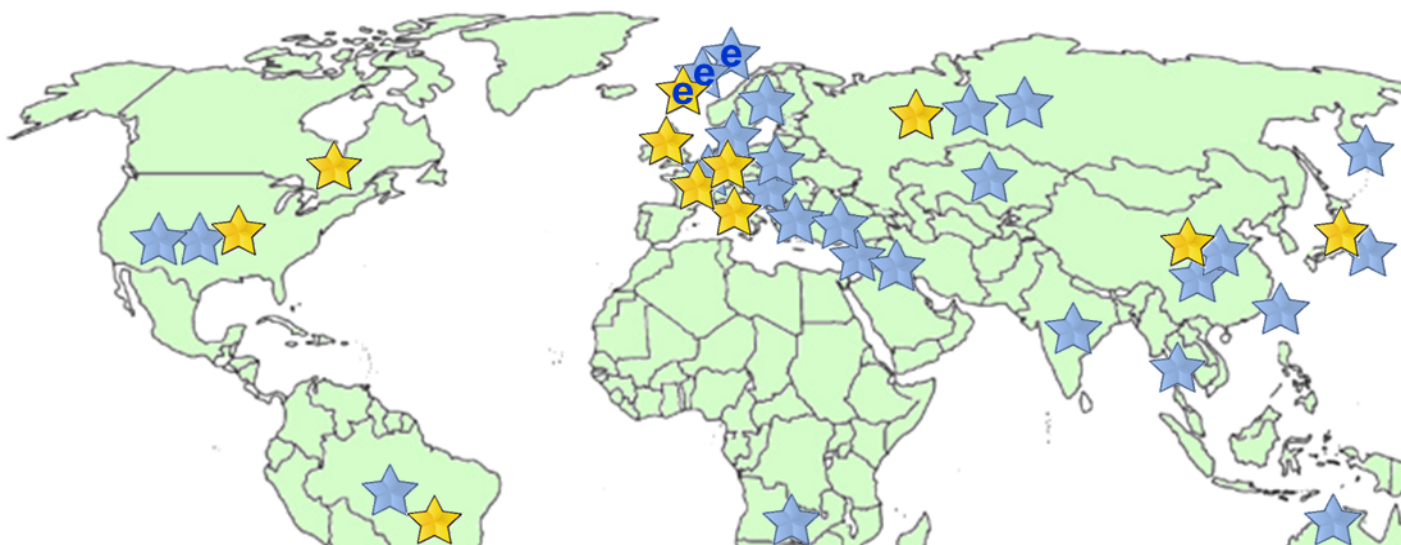


★ CCSDS – An Agency-Led International Committee

- ✧ Currently 11 Member agencies
- ✧ Currently 29 Observer Agencies
- ✧ Agencies represent 27 nations (plus European orgs)
- ✧ Currently 151 Commercial Associates
- ✧ ~160-180 attendees at Spring/Fall meetings

★ Also functions as an ISO Subcommittee

- ✧ TC20/SC13 - Space Data & Info Transfer Systems
- ✧ Represents 20 nations

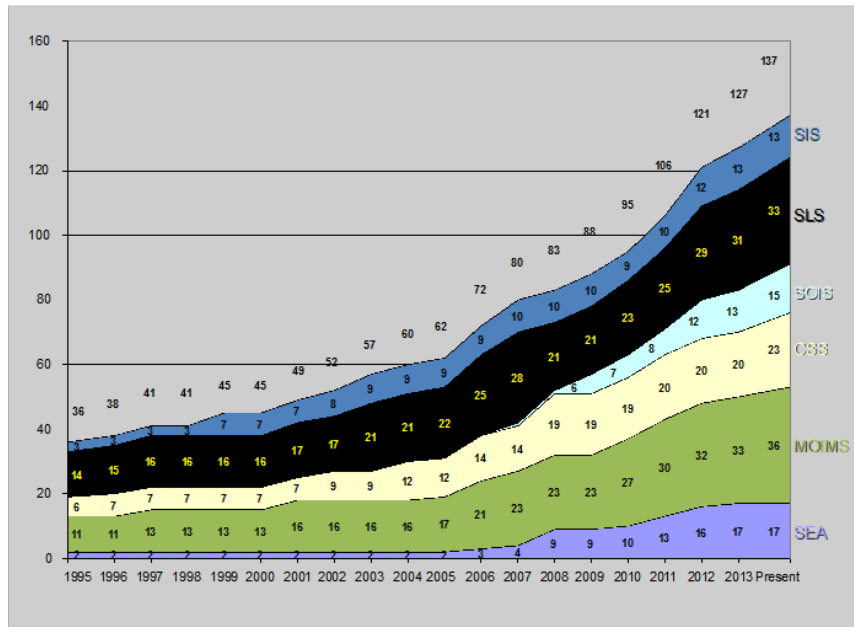


★		OBSERVER AGENCIES
		ASA/Austria
		BFSP0/Belgium
		CAS/China
		CAST/China
		CLTC/China
		CSIR/South Africa
		CSIRO/Australia
		DCTA/Brazil
		DN5C/Denmark
		EUMETSAT/Europe
		EUTELSAT/Europe
		GISTDA/Thailand
		HNSC/Greece
		IKI/Russia
		ISRO/India
		KARI/Korea
		KFKI/Hungary
		MOC/Israel
		NCST/USA
		NICT/Japan
		NOAA/USA
		NSARK/Kazakhstan
		NSPO/Taiwan
		SSC/Sweden
		SSO/Switzerland
		SUPARCO/Pakistan
		TsNIIMash/Russia
		TUBITAK/Turkey
		USGS/USA
★		MEMBER AGENCIES
		ASI/Italy
		CNES/France
		CNSA/China
		CSA/Canada
		DLR/Germany
		ESA/Europe
		FSA/Russia
		INPE/Brazil
		JAXA/Japan
		NASA/USA
		UKSA/UK

CCSDS Overview



Active Publications



Currently Active Publications: **137**

Normative (Blue & Magenta): **86**

Informative (Green): **50**

Experimental (Orange): **1**

Downloadable for free from

www.ccsds.org

All major pubs since 1982: **~283**

(Some were historical mission needs or superseded technology)

694 space missions have adopted and used various CCSDS standards



Overview - End-to-End Architecture

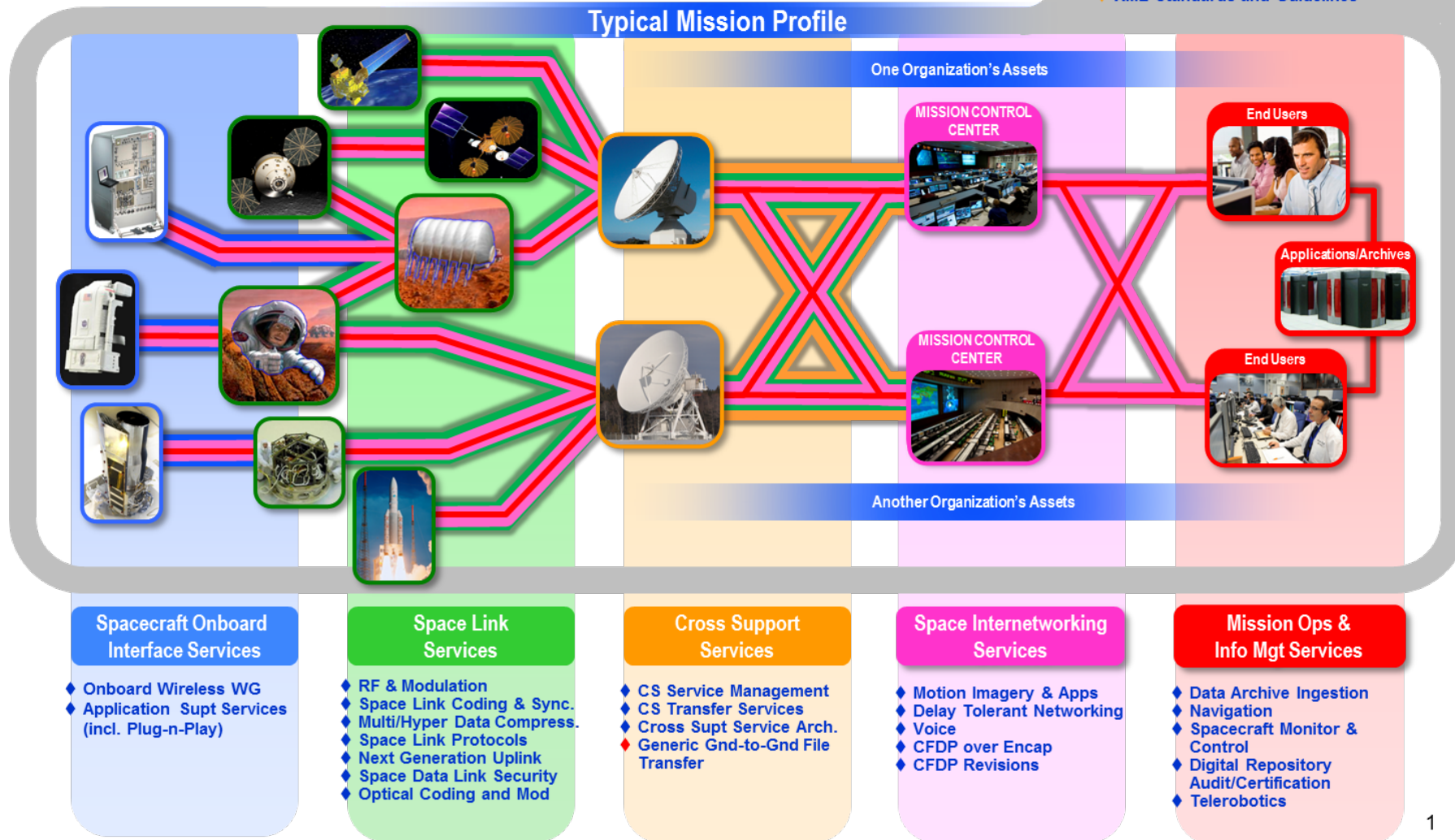
Six Technical Areas, Twenty-Seven Teams

- ◆ Working Group (producing standards)
- ◆ Birds-Of-a-Feather stage (pre-approval)
- ◆ Special Interest Group (integration forum)

Systems Engineering

- ◆ Security
- ◆ Delta-DOR
- ◆ Timeline Data Exchange
- ◆ XML Standards and Guidelines

Typical Mission Profile



Mission Benefits of Using Interoperable Data System Standards



- Lowers **Cost** of space communication and mission systems
 - Major companies produce subsystems which meet them
 - Compatible ground systems can fill in the gaps
 - Facilitates implementation of complex international mission systems
- Lowers **Risk** for space mission operation
 - Robust coverage for critical human exploration needs or events
 - Facilitates seamless backup mission systems
- Enables **Collaborative** space missions with other nations
 - **Aligned with NASA's Strategic Plan**
 - Example: "trading" a ride for an instrument for cross support communications

Agency Benefits of Using Interoperable Data Systems Standards



- Internationally Interoperable standards have enabled **\$100s of M** in cross support for NASA and Partners
- Promotes robust global interoperability
- Saves money for NASA and partners
- Key to enabling missions such as:
 - **Mars Science Laboratory / NASA**
 - **MOM / ISRO**
 - **HTV, ALOS II / JAXA**
 - **MARS InSight / NASA**
- Essential element in successful implementation of the Global space operations Architecture
 - **Critical to meeting SCan Driving Requirements**



IOAG liaison with ISECG



As a first step, the current ISECG Global Exploration Roadmap has included in Chapter 3, “A Long-Range Human Exploration Strategy,” a section on *Standards to Promote Interoperability*:

“Agencies participating in IOAG, SFCG, and CCSDS have collaborated on establishing data communications and mission operations architectures, coordinating spectrums for space communications, and technical standards for cross support which take advantage of current and anticipated state-of-the-art technologies.

These teams have developed service catalogs and technical standards which respond to the anticipated needs of future exploration missions. These services and standards will enable highly internetworked mission operations and facilitate the integration of new partners into complex human space exploration missions.”

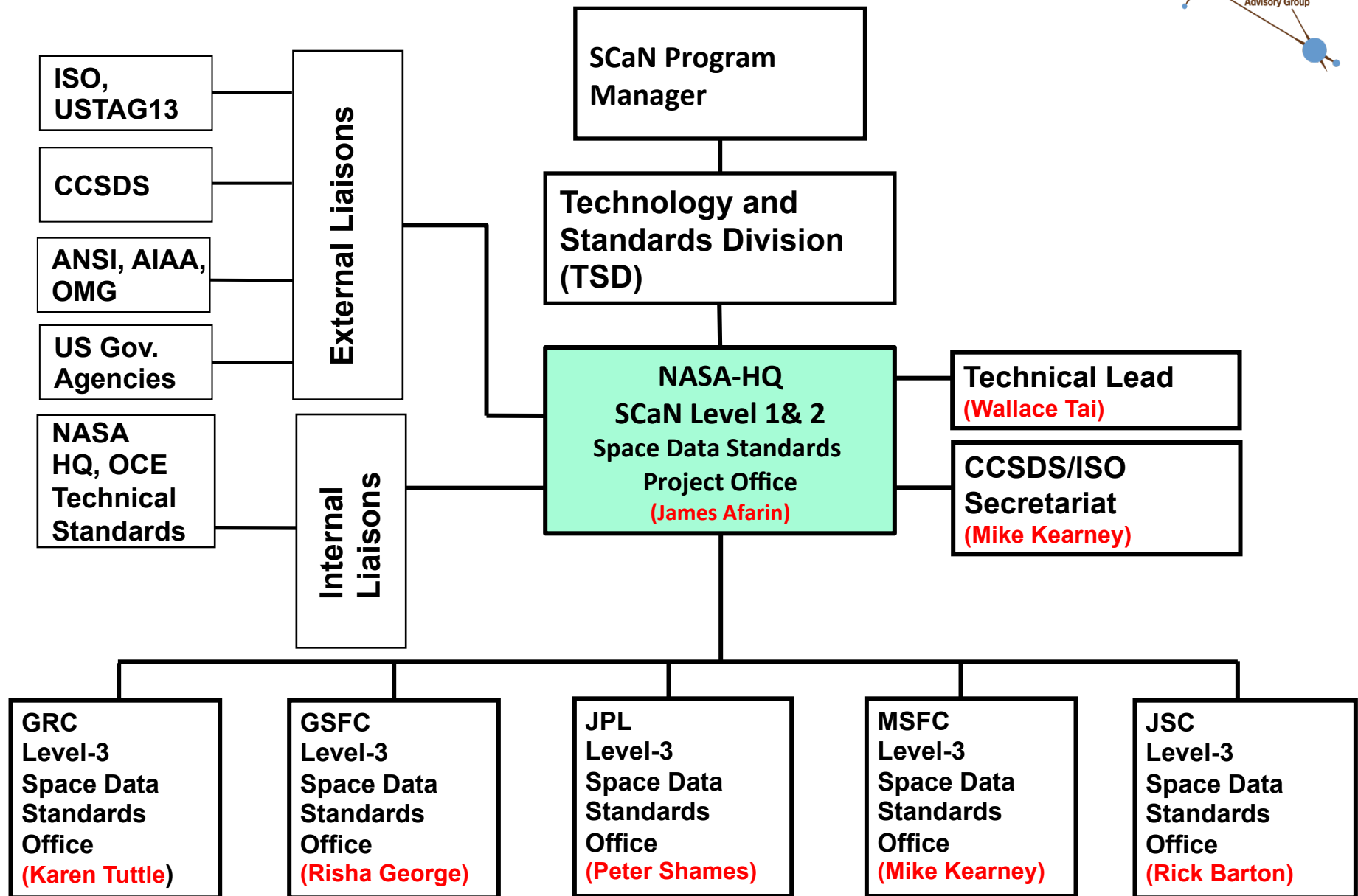
The IOAG agencies look forward to working with you to create the future for Human Space Exploration!

Points of Contact



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- ◆ Wallace Tai (CCSDS Technical Lead)
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 - ◆ (818) 354-7561
- ◆ SCaN Customer Commitment Offices
 - ◆ GSFC - Network Integration Management Office
 - ◆ JPL - Customer Commitment Office

NASA Data Standards Project Organization





BACK-UP



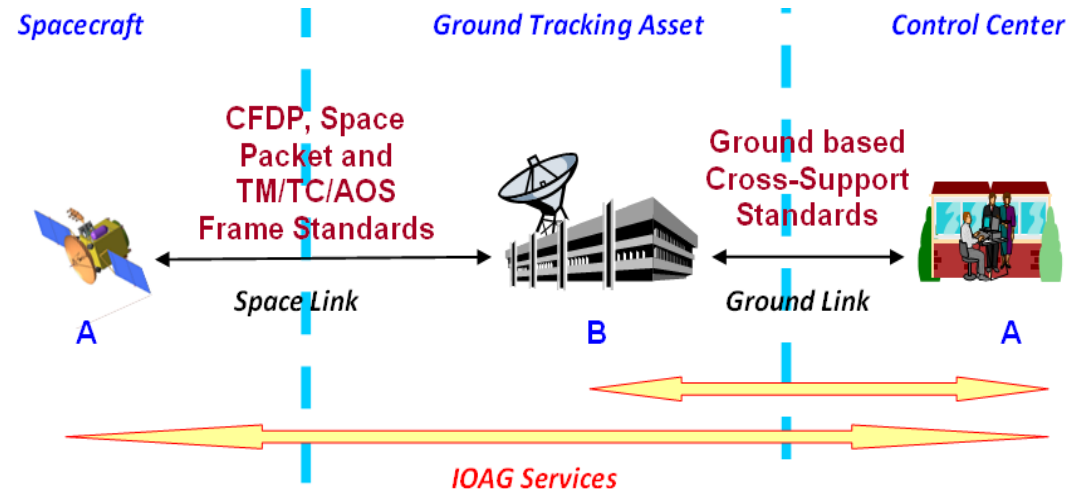
IOAG Service Catalog #1

Issue 1, Revision 3, Approved 04 March, 2010



IOAG Service Catalog #1 addresses current mission scenarios where access is provided to a single space/ground data link.

- a) Forward Data Delivery Services Group
- b) Return Data Delivery Services Group
- c) Radio Metric Services Group
- d) Service Management functions



CORE SERVICES:

- **Forward CLTU Service** (SLE Forward CLTU)
- **Return All Frames Service** (SLE Return All Frames)
- **Return Channel Frames Service** (SLE Return Channel Frames)
- **Validated Data Radio Metric Service** (CSTS Offline Radio Metric, over CSTS File Transfer)

EXTENDED SERVICES:

- **Forward Space Packet Service** (SLE Forward Space Packet, existing)
- **Forward Synchronous Encoded Frame Service** (SLE Forward Synchronous Encoded Frame) → For AOS Frames (mainly)
- **Forward File Service** (CSTS Forward File Service, over CSTS Transfer File)
- **Return Operational Control Field Service** (SLE Return OCF, existing)
- **Return Unframed Telemetry Service** (CSTS Return Unframed Telemetry) → no TM format
- **Return File Service** (CSTS Return File, over CSTS File Transfer)
- **Raw Data Radio Metric Service** (CSTS Real Time Radio Metric)
- **Delta DOR Service** (CSTS D-DOR Data, over CSTS File Transfer)

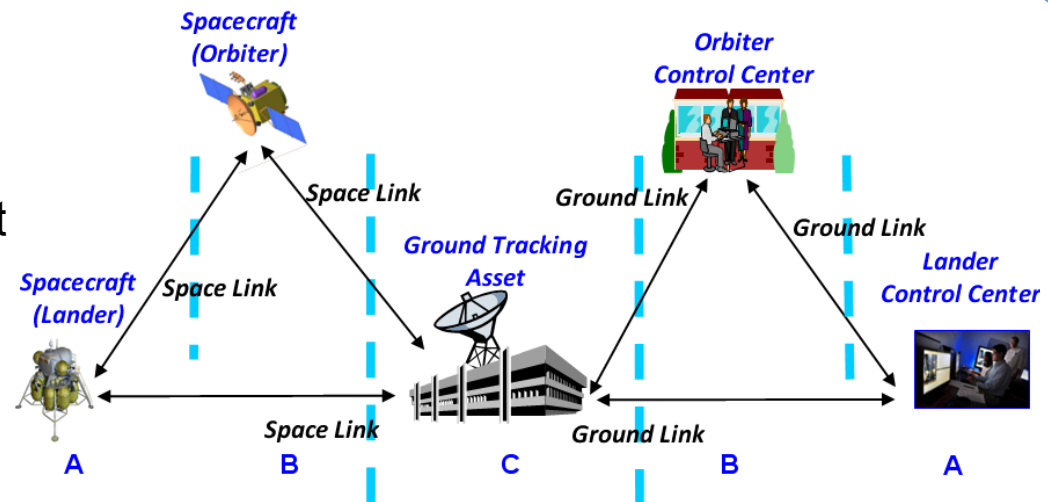


IOAG Service Catalog #2

Issue 1, Revision 30 Approved 18 February 2011

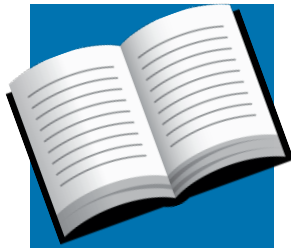


IOAG Service Catalog #2 addresses space communication services for in-space relay and network cross-support scenarios which would enable future Solar System Internetworking (SSI)



- a) Forward + Return Internetworking for DTN
- b) Forward + Return Internetworking for IP
- c) Forward Last Hop Delivery + Return First Hop Delivery (*e.g.: non networked commanding or essential telemetry*)
- d) Radiometric services (*e.g.: Proximity-1 radio metric data*)
- e) Time Synchronization Service
- f) SSI Network Management functions

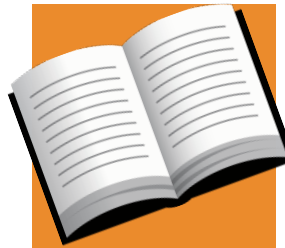
Field Guide to CCSDS Book Colors



BLUE BOOKS

Recommended Standards

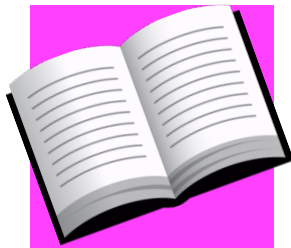
Normative and sufficiently detailed (and pre-tested) so they can be used to directly and independently implement interoperable systems (given that options are specified).



ORANGE BOOKS

Experimental

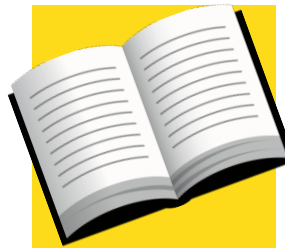
Normative, but may be very new technology that does not yet have consensus of enough agencies to standardize.



MAGENTA BOOKS

Recommended Practices

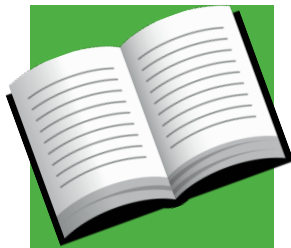
Normative, but at a level that is not directly implementable for interoperability. These are Reference Architectures, APIs, operational practices, etc.



YELLOW BOOKS

Administrative

CCSDS Procedures, Proceedings, Test reports, etc.



GREEN BOOKS

Informative Documents

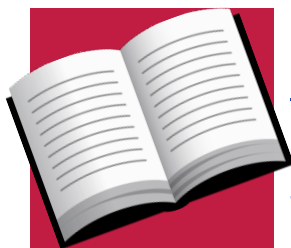
Not normative. These may be foundational for Blue/Magenta books, describing their applicability, overall architecture, ops concept, etc.



SILVER BOOKS

Historical

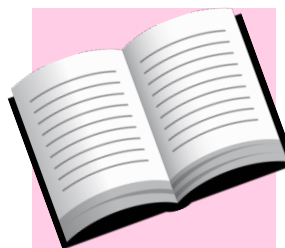
Deprecated and retired documents that are kept available to support existing or legacy implementations. Implication is that other agencies may not cross-support.



RED BOOKS

Draft Standards/Practices

Drafts of future Blue/Magenta books that are in agency review. Use caution with these... they can change before release.



PINK BOOKS/SHEETS

Draft Revisions For Review

Draft Revisions to Blue or Magenta books that are circulated for agency review. Pink Books are reissues of the full book, Pink Sheets are change pages only.



IOAG Top Priorities: Game changing / Critical needs



- **Coordination on Space Debris**
- **Increase to very high data rates**
- **Service Management of the Service Catalogs**
- **End-to-end file transfers**
- **Security**
- **Coordination on solar system and exploration missions**
- **Mission Operations**

- **Conjunction data message: standard in final production at CCSDS**
- **LDPC codes (3 mission models): standards available now from CCSDS**
- **Service Management: standard "under revision" at CCSDS**
- **CFDP: standard available and implementation standards (CFDP over xxx) in final production in CCSDS**
- **Space Data Link Security: standard in preparation at CCSDS.**
- **Delta DOR: standards available and others in preparation at CCSDS**
- **Mission Operations Core Services: standards available and others in preparation at CCSDS**





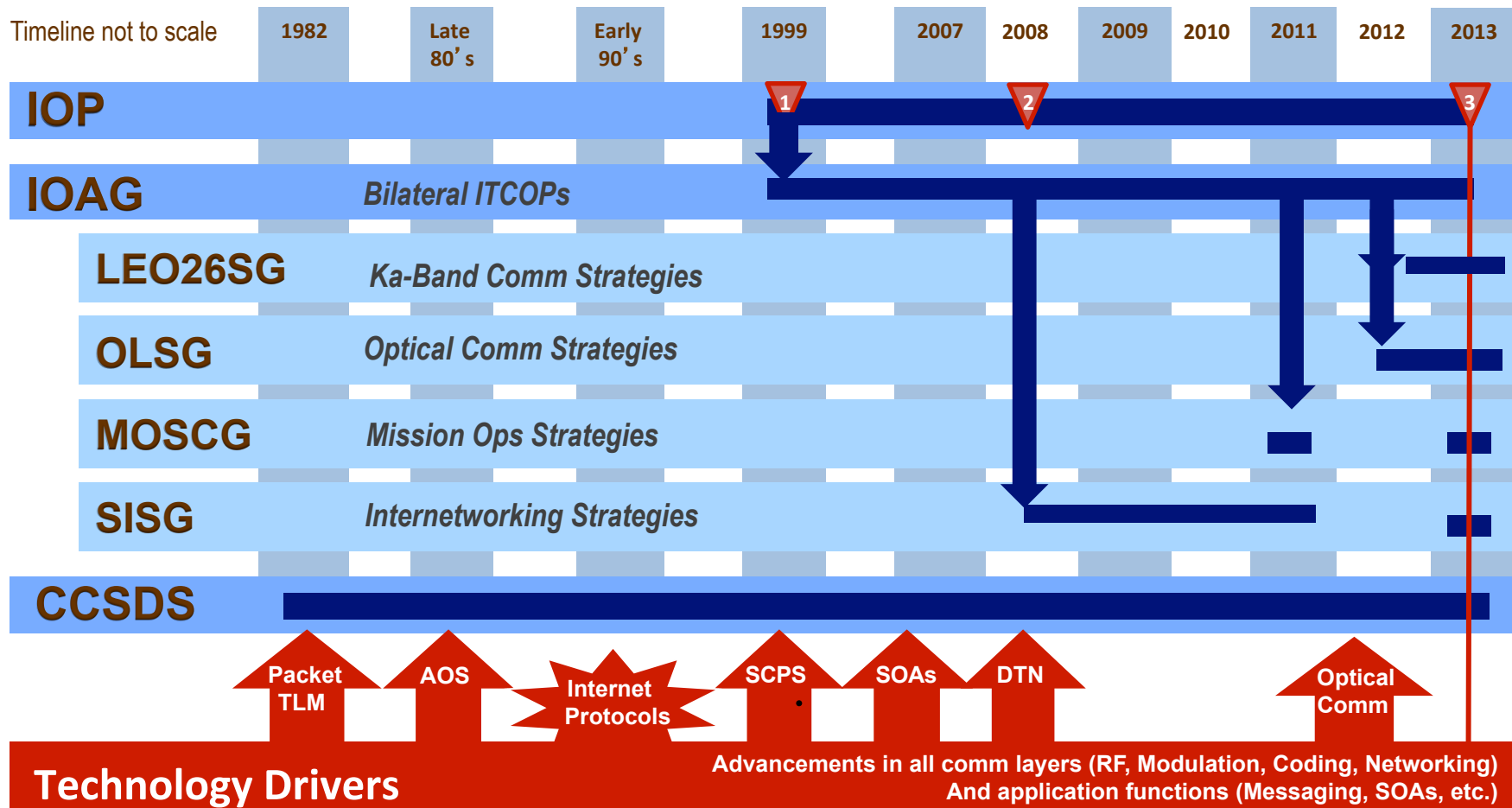
IOP, IOAG, and CCSDS Overview

Technology Drivers and Strategy Groups

Timeline

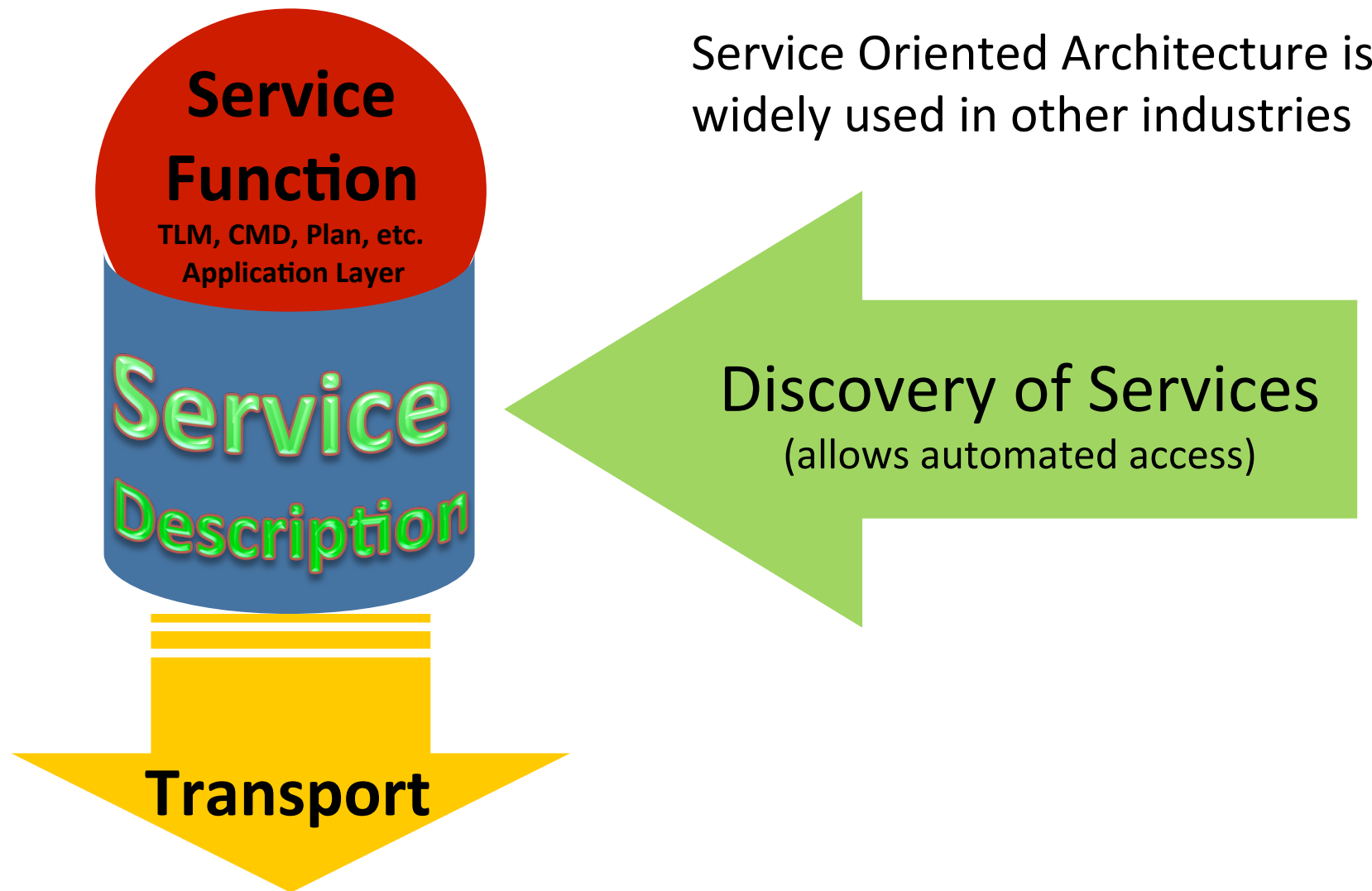


Capitalizing on advanced technology when the timing is right.



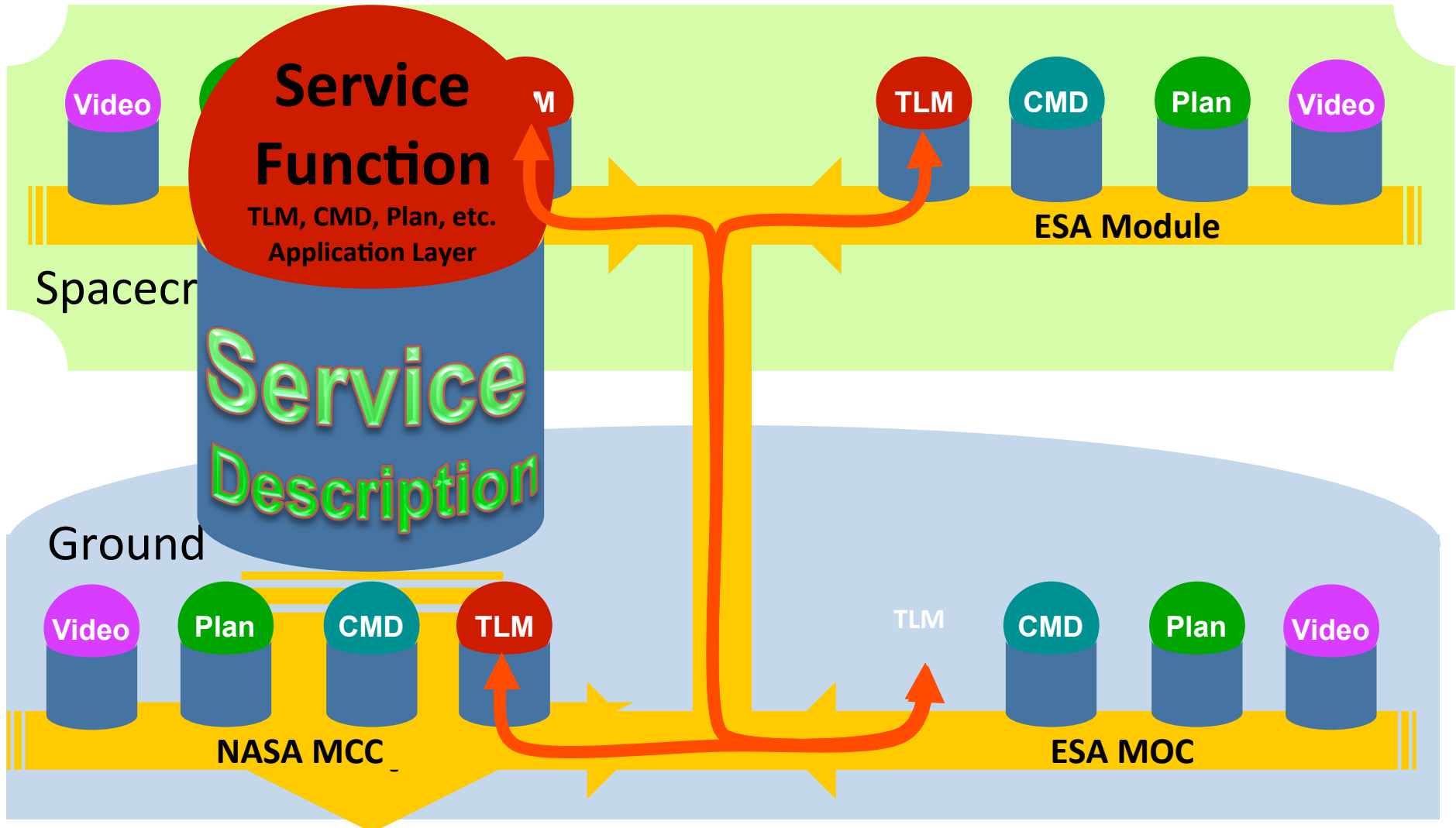


How Does A MO Service Oriented Architecture Work?



How Can This CCSDS MO Service Architecture Work?

Cross-support is based on operational configuration and on security
→ NOT on a new software development project.



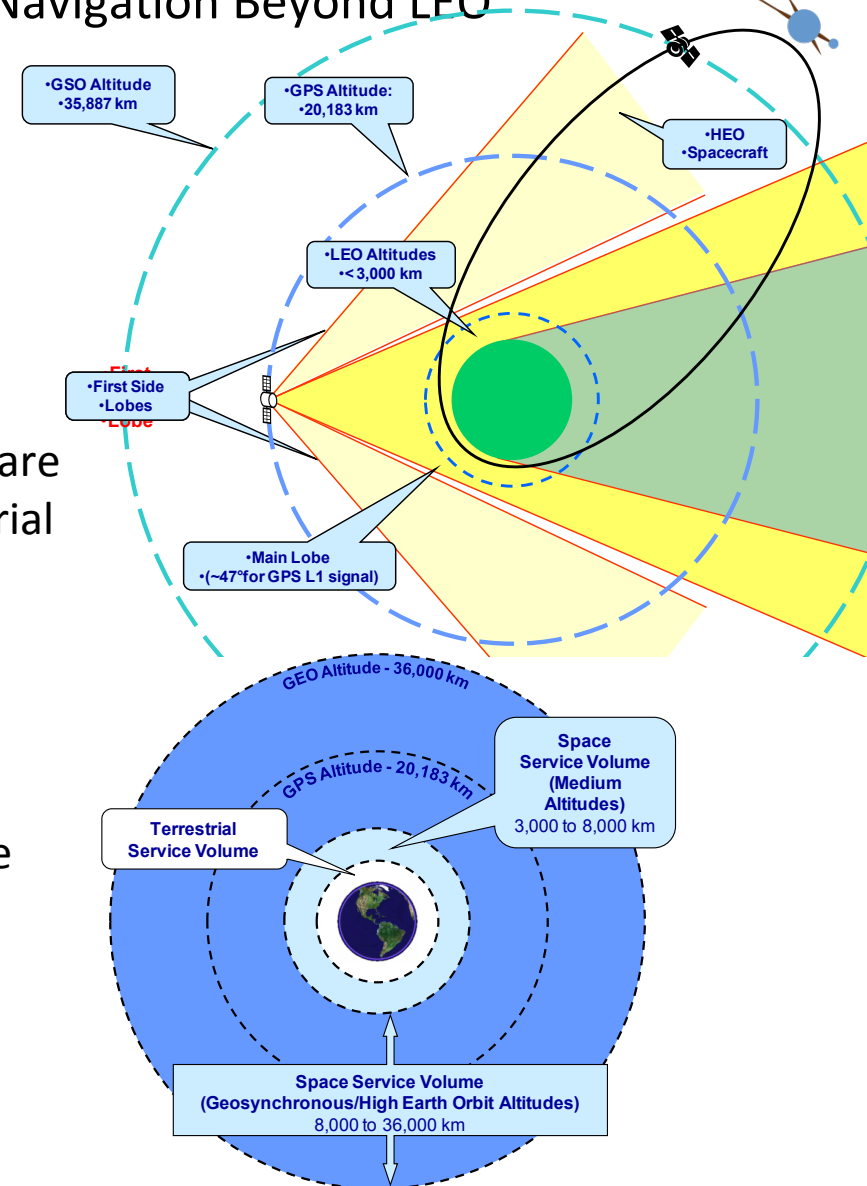


Liaison with the ICG

GNSS Space Service Volume: Navigation Beyond LEO



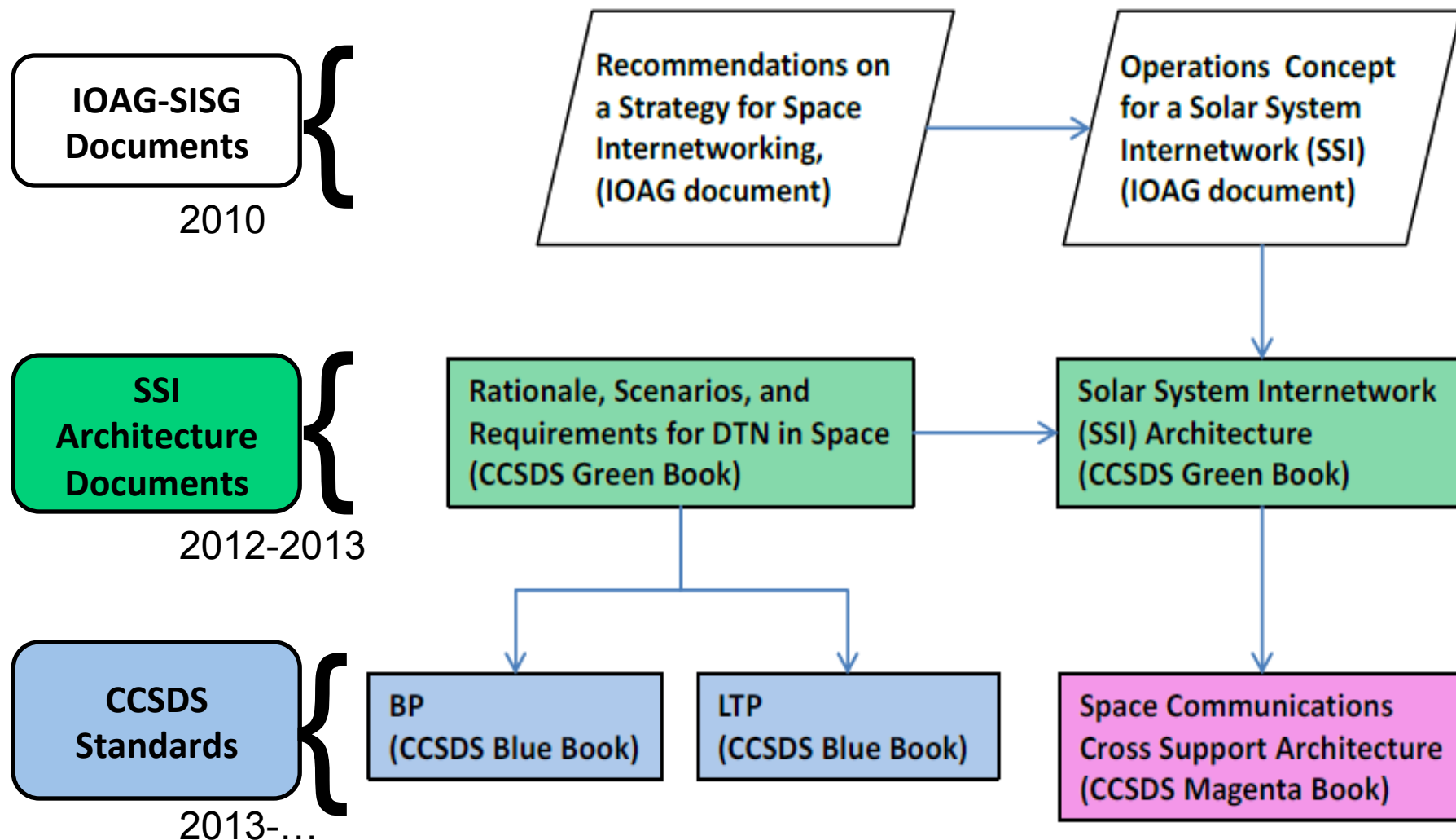
- 100s of space missions rely on GNSS for navigation
- IOAG established a liaison to the ICG
 - Represent these equities
 - Foster interoperability for space users
- While most space missions using GNSS today are in Low Earth orbit and covered by the Terrestrial service volume
- Future missions will use
 - SSV for Medium Altitudes:
 - 3,000 to 8,000 km altitude
 - One-meter orbit accuracies are feasible
 - SSV for GSO/HEO Altitudes:
 - 8,000 to 36,000 km altitude



IOAG has observer status in the ICG

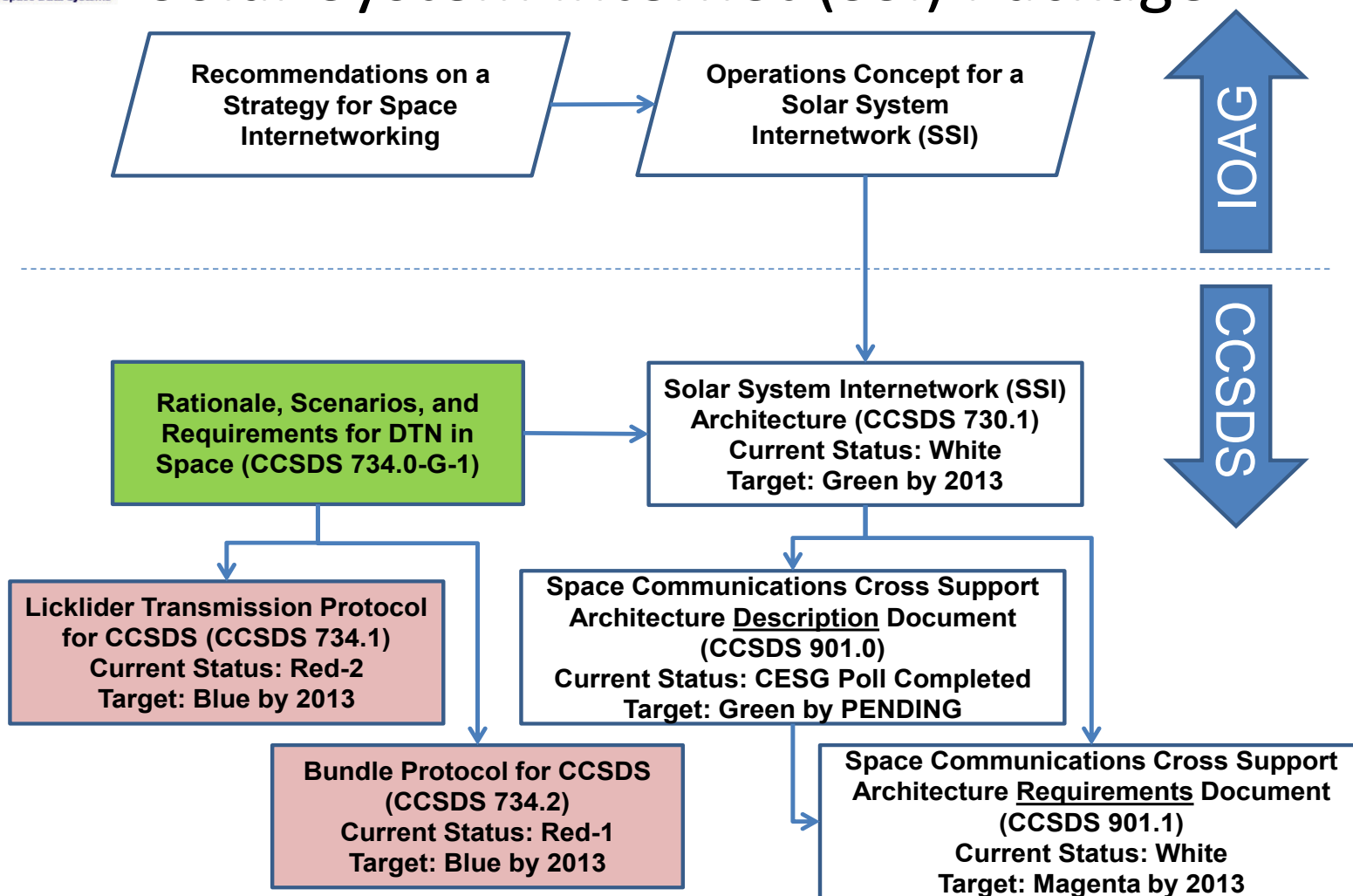


SSI Architecture Documentation



CCSDS Response to IOAG

Solar System Internet (SSI) Package



Bundle / DTN Security not shown (not yet in CCSDS Programme of Work)



CCSDS Overview

Organizational Interrelationships



IOAG provides to CCSDS the IOAG priorities and guidance for future communications/operations plans

CCSDS Participants bring in other agencies/industry inputs, mission needs and technology drivers.

CCSDS participant inputs bring in needs of individual organizations

Technology Drivers

CCSDS MEMBER AGENCIES (11) direct inputs
OBSERVER AGENCIES (28) direct inputs
MISSIONS AND PROGRAMS with direct funding



SFCG, ICG, and other peer groups

Study Groups

- SISG
- OLSG
- MOSCG
- LEO26SG

Close Coordination for Discipline Topics